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Downed Woody Material in Southeast Alaska Forest Stands

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Abstract

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Data collected in conjunction with the multiresource inventory of southeast Alaska in 1985-86 included downed wood along 234 transects at 60 locations. Transects occurred in 11 forest types and 19 plant associations within the entire southeastern Alaska archipelago. Downed wood weights in forest types ranged from 1232 kilograms per hectare (0.6 ton per acre) in muskeg (shore pine) stands to 117 483 kilograms per hectare (52.4 tons per acre) in western redcedar stands. In plant association terminology, downed wood weights ranged from 3115 kilograms per hectare (1.4 tons per acre) in the shore pine/crowberry association to 156 083 kilograms per hectare (69.6 tons per acre) in western hemlock/blueberry associations.

Keywords: Forest biomass, downed woody fuels, coarse woody debris, Alaska.

Summary

Good management decisions require knowledge about resources beyond just marketable products. Coarse woody debris is one resource often overlooked, yet it is an important aspect of old-growth forests, an important wildlife habitat component, and a factor in watershed management.

Southeast Alaska, known for its high aesthetic recreational values, high timber yields, and productive wildlife and fish habitat, is part of the only temperate coniferous rain forest in the world. Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) are the dominate species of the area with other species occurring less frequently.

Data on downed woody fuel were collected in conjunction with a multiresource inventory, analyzed, and are reported in terms of forest types and plant associations. The sample was fairly small, with only 234 transects at 60 locations, and resulting standard errors are high. To reduce standard errors, the 11 forest types and 19 plant associations initially identified were tested and grouped into nine combinations of forest types and seven combinations of plant associations. The results are presented in six tables in this report.

For the 78 samples in predominant Sitka spruce and western hemlock stands, downed wood weights averaged 74 332 kilograms per hectare (33.2 tons per acre) when data from all stands were used, with slightly lower weights for the 72 samples in old-growth stands and considerably higher weights in six cutover stands. Results of this study compare favorably with those reported for other studies installed in similar stands on the Olympic Peninsula, Washington.

Downed woody material is not much of a problem in southeast Alaska, as the nature of the nearly fireproof rain forest prevents fire hazard from becoming severe. The downed woody material may improve wildlife habitat from a cover standpoint but hamper wildlife mobility. The material may be a detriment to seedling establishment after logging, but otherwise, the downed woody material does not seen to be a problem for Alaskan foresters.

Introduction

Land managers today need much more information than they currently have to manage and place values on all resources and assure continued biological diversity of both plants and animals. Coordinating outdoor recreation, range and timber management, fish and wildlife habitat, watershed, and wilderness resources requires a broad data base of resource availability and descriptions (Martin and others 1979). Managers also must recognize the importance of coarse woody debris in maintaining stands in old-growth condition and in managing fish and wildlife habitat, both terestrial and stream (Samson and others 1989).

Woody litter provides a unique habitat for both floral and faunal species; it replenishes nutrients and provides raised sites for seedlings to become established, particularly on wet organic soils (Franklin and others 1981). Maxwell and Ward (1981), in their forest fuel loading studies, recognized the importance of describing downed wood for land management planning. Combining downed wood with overstory and understory data provides a good data base for multiresource considerations in project areas because downed wood is part of the structural and functional components of the ecosystem (Franklin and others 1981, Harmon and others 1986).

Uneven-aged old-growth stands predominate in the rain forests of southeast Alaska, but younger even-aged stands are interspersed throughout. Southeast Alaska is known for its high aesthetic and recreational values, high timber yields, and valuable fish and wildlife habitat. Stands are composed primarily of western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.). These two species occur along the North American coast from Prince William Sound to northern California. In southeast Alaska, the hemlock-spruce belt is about 210 kilometers (130 miles) wide, and the species mix ranges from pure hemlock to pure spruce, with less frequent occurrence of western redcedar (*Thuja plicata* (Donn ex D. Don)), Alaska-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach), and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.) (Ruth and Harris 1975).

Stands of black cottonwood (*Populus trichocarpa* Torr. & Gray), red alder (*Alnus rubra* Bong.), or shore pine (*Pinus contorta* var. *contorta* Dougl. ex Loud.) occasionally are found. Common understory shrub species found throughout southeast Alaska include blueberry (*Vaccinium* spp. L.), crowberry (*Empetrum nigrum* L.), devils club (*Oplopanax horridum* (Sm.) Miq.), and yellow skunk cabbage (*Lysichitum americanum* Hultén & St. John).

In southeast Alaska, downed woody materials accumulate for many years, as disintegration over time is usually the only loss in these nearly fireproof rain forests. Large quantities of materials can accumulate, which not only affect the establishment of new forest trees but also may provide wildlife cover and, at the same time, restrict the movement of wildlife. This is particularly important to the Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) that use these old-growth stands as quality winter habitat (Wallmo 1981).

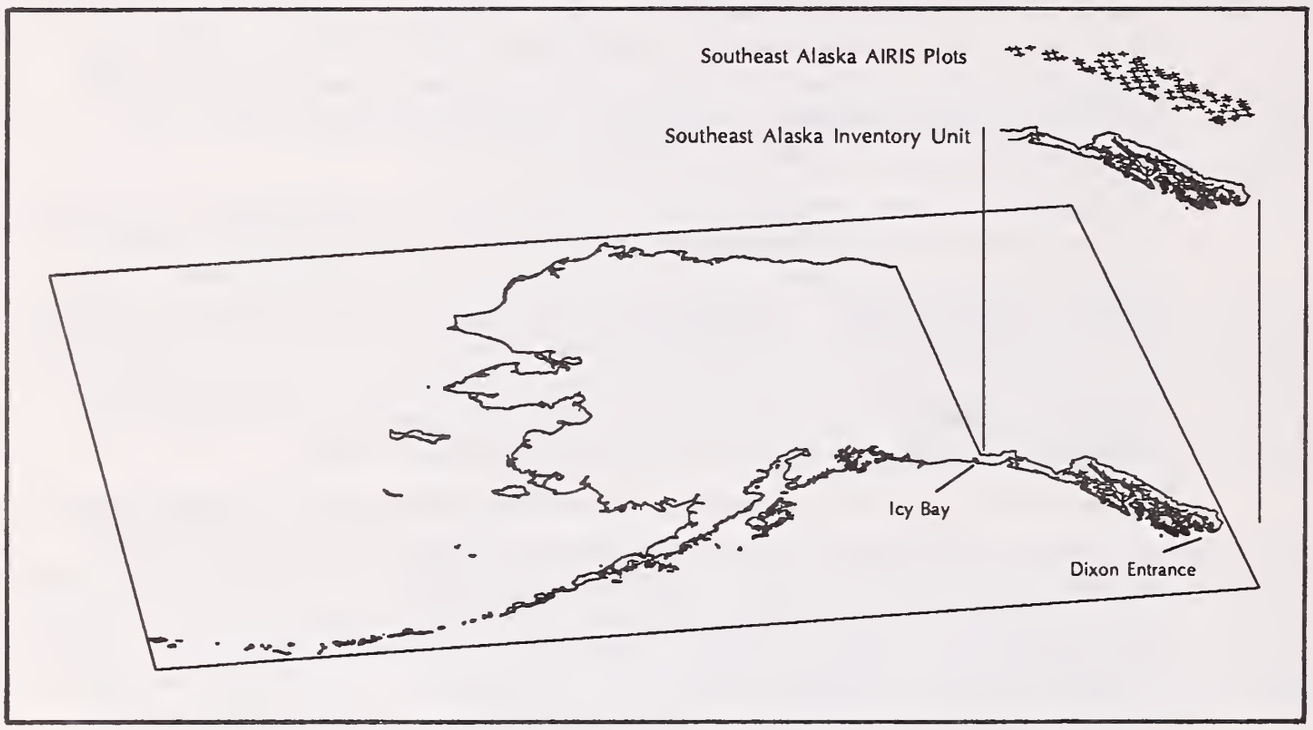

Figure 1—Transect locations for this study, southeast Alaska.

Location and Methods

The Alaska Forest Inventory and Analysis Project has been collecting multiresource data for many years in interior Alaska. A four-phase sample design was used that takes advantage of satellite data, two scales (1:60,000 and 1:5,000) of aerial photography, and ground truth data collection. Inventories of downed woody material on ground plots were begun in 1983 for the Tanana River basin and continued in southeast Alaska coastal stands in 1985. For this study, plots were established from Dixon Entrance in the south to Icy Bay in the north (fig. 1).

Downed wood was sampled by using the planer intersect technique (Brown 1974). These data were collected to provide a general description of downed wood by forest types (Eyre 1980) and plant associations[1] [2] (Martin 1989). Forest types are defined by the Society of American Foresters and are based on the dominant tree species present, whereas plant associations are defined by the dominant tree overstory and primary understory species. Descriptions presented are representative but may not be precise as the sample size was quite small with limited fuel transects at any one location.

[1] DeMeo, T. 1989. Preliminary forest plant association management guide, Ketchikan Area, Tongass National Forest. 164 p. Draft USDA Forest Service report. On file with: Tongass National Forest, Federal Building, Ketchikan, AK 99901.

[2] Pawuk, W.H.; Kissinger, E.J. 1989. Preliminary forest plant associations of the Stikine Area, Tongass National Forest. 26 p. Draft USDA Forest Service report. On file with: Tongass National Forest, P.O. Box 309, Petersburg, AK 99833.

The sample size for downed wood was fairly small with only 234 transects at 60 locations. Sample plot size was selected by use of the Alaska Integrated Resource Inventory System (AIRIS) sample design (LaBau and Schreuder 1983). In this design, 8-hectare (20-acre) ground inventory plots were located on a 40-kilometer (25-mile) grid across the State. Each ground plot was stratified according to vegetation strata classes on the plot. Then, for each vegetation class, two horizontal-vertical vegetation profile plots were located at overstory inventory points (Larson and Mead 1983), and a downed woody material transect (Brown 1974) was measured across the 11.28-meter (37-foot) horizontal-vertical profile plot.

Duff depth and fuel height were measured twice within the first meter of the transect. Intercepted downed woody particles 0-5.9 millimeters (0-1/4 inch) and 6-24.9 millimeters (1/4-1 inch) in size were tallied for the first 2 meters (6-1/2 feet) of the transect; particles 25-75 millimeters (1-3 inches) in size were tallied in the first 4 meters (13 feet); and all material larger than 75 millimeters (3 inches) was measured and diameters were recorded by sound or rotten classes along the entire 11.28 meters (37 feet). The percent slope of the transect completed the measurements.

Brown's (1974) computations for downed woody material were used, including the slope correction factor, constants for the composite squared average-quadratic-mean diameters, specific gravity coefficients, and average secant of nonhorizontal particle angles. The data were summarized by forest type and by plant association.

Results

Because of the sample design, the number of transects per forest type or plant association differed considerably; three forest types had only two transects over the entire area. In the first analysis, the largest class had 51 transects out of the total 234 transects inventoried. Of these, 138 transects also were classified by plant associations for southeast Alaska (Martin 1989; see footnotes 1 and 2). The remaining 96 transects had no comparable defined plant association descriptions. Data on downed wood were collected as "additional" information to provide a general descriptor of the site, but this had to be done within time and budget constraints.

Tests of significance among types resulted in grouping 11 forest types into 9 classes and 19 plant associations into 7 classes. Sample sizes ranged from 2 in the smallest class to 78 in the largest class. Brown (1974) recommends 15 to 20 sample transects at each location, so at the 60 locations sampled, there should have been at least 900 transects to achieve Brown's recommended minimum.

Total weight of downed woody material in the forest types ranged from 1232 kilograms per hectare (0.6 ton per acre) in shore pine stands to 117 483 kilograms per hectare (52.4 tons per acre) in western redcedar stands (tables 1 and 2). Forest types with high timber volume had higher downed wood weights than the marginal types. Thus, western hemlock-Sitka spruce and Alaska-cedar types had high levels of downed woody biomass. The high weights of downed woody material in western redcedar stands may be the result of the slow decay rate of this species.

Red alder also had a high fuel loading—nearly equal to Alaska-cedar biomass. This probably is an artifact of the small sample, as alder usually decays rapidly. The black cottonwood stands had little downed woody biomass, but this type had only two transects that occurred in open stands typical of those found at the north end of the unit near Yakutat. Noncommercial softwoods and nonforest types had fairly low biomass of downed woody materials (table 1).

Table 1—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth by forest types in metric units

Forest type	Sample size	Size class of materials (mm)					Total	Std. dev. of total	Average diameter (mm)		Duff depth	Fuel depth
		0-6	6-25	25-75	75+sound	75+rotten			75+sound	75+rotten		
	Number	*Kilograms per hectare*							*Centimeters*			
Mountain hemlock	51	1995	1367	1076	11 589	12 419	28 446	54 673	19.8	24.9	10.7	3.0
Western hemlock-Sitka spruce	78	1681	2309	3228	25 465	41 649	74 332	117 348	20.6	27.2	25.6	7.1
Western redcedar	15	269	1009	1995	62 944	51 266	117 483	229 518	28.2	36.1	11.7	13.2
Alaska-cedar	21	471	1524	1300	45 617	13 226	62 138	114 995	23.6	22.4	34.3	7.9
Shore pine	16	112	134	336	650	0	1232	2802	15.0	0	73.2	1.0
Noncommercial softwoods	2	112	1255	3743	3161	0	8241	11 424	11.9	0	2.0	10.9
Black cottonwood	2	112	2466	4326	695	0	7599	5626	6.1	0	8.1	58.9
Red alder	2	1233	2286	3049	54 068	1636	62 272	86 459	23.9	8.9	2.5	11.4
Nonforest	47	403	1323	2981	247	1861	6815	13 853	10.4	19.6	5.3	2.3

Table 2—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth by forest types in English units

Forest type	Sample size	Size class of materials (in)						Std. dev. of total	Average diameter (in)		Duff depth	Fuel depth
		0-1/4	1/4-1	1-3	3+sound	3+rotten	Total		3+sound	3+rotten		
	Number	*Tons per acre*							*Inches*			
Mountain hemlock	51	0.9	0.6	0.5	5.2	5.5	12.7	24.4	7.8	9.8	4.2	1.2
Western hemlock-Sitka spruce	78	.7	1.0	1.4	11.4	18.6	33.2	52.3	8.1	10.7	10.1	2.8
Western redcedar	15	.1	.5	.9	28.1	22.9	52.4	102.4	11.1	14.2	4.6	5.2
Alaska-cedar	21	.2	.7	.6	20.4	5.9	27.7	51.3	9.3	8.8	13.5	3.1
Shore pine	16	.1	.1	.1	.3	0	.6	1.2	5.9	0	28.8	.4
Noncommercial softwoods	2	.1	.6	1.7	1.4	0	3.7	5.1	4.7	0	.8	4.3
Black cottonwood	2	.1	1.1	1.9	.3	0	3.4	2.5	2.4	0	3.2	23.2
Red alder Alder	2	.6	1.0	1.4	24.1	.7	27.8	38.6	9.4	3.5	1.0	4.5
Nonforest	47	.2	.6	1.3	.1	.8	3.0	6.2	4.1	7.7	2.1	.9

Plant associations were defined to help foresters, wildlife biologists, and managers better understand the ecosystem by providing descriptions of potential vegetation. To properly manage a forest, managers require knowledge of existing and potential vegetation, condition of the site, and site response to management activities. Inventories yield information on existing conditions, and plant associations indicate what the site potential might be. Plant associations may or may not coincide with forest type definitions. Plant association was determined for each plot where possible, and downed woody biomass was examined from this perspective.

In plant associations, downed woody weights ranged from 3115 kilograms per hectare (1.4 tons per acre) in shore pine/crowberry associations to 156 083 kilograms per hectare (69.6 tons per acre) in the western hemlock-redcedar/blueberry association (tables 3 and 4).

When the data were examined by plant associations, the types with western redcedar had the highest biomass of downed woody materials. These were followed by the associations with high timber volume, then by associations not as commercially important for timber production (tables 3 and 4).

Because of the relatively few transects for each strata class, standard errors of total weights are high. In all but two classes, the standard errors exceeded the mean weights. When one knows that, it is not too surprising that the 11 original forest classes and 19 plant associations, when tested for significant differences, were combined in the 9 forest classes and 7 associations reported.

No significant differences were found for the three forest types of western hemlock, Sitka spruce, or western hemlock-Sitka spruce mixed. Of the three types, the mixed hemlock-spruce had the highest average weight and the greatest standard error. As no significant differences could be detected among these three classes, they were grouped and are reported as western hemlock-Sitka spruce in tables 1, 2, 5, and 6.

The five plant associations inventoried with western hemlock as the dominant component likewise were grouped into one class following statistical tests to determine their compatibility. The four associations dominated by mountain hemlock also were combined into one class, as were the three associations dominated by western hemlock-western redcedar, the three mixed-conifer-dominated associations, and the two Sitka spruce-dominated associations.

There are few data in the literature to compare with the stands found in coastal Alaska; however, downed wood accumulation in southeast Alaska is comparable to that of the Olympic Pensinula and Pacific Northwest coast old-growth forest stands. Martin and others (1979) state that in an old-growth broadcast burn of western hemlock stands on the Olympic Peninsula, 41 021 kilograms per hectare (18.3 tons per acre) or 39 percent of the down and dead fuels were consumed; the implications that 105 183 kilograms per hectare (46.9 tons per acre) of down and dead material were on the site before the burn. This is about 20 percent higher than the 87 871-kilograms-per-hectare (39.2-tons-per-acre) weight for combined western hemlock-Sitka spruce stands reported in this paper.

Table 3—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth by plant association or habitat types in metric units

Habitat type	Sample size	Size class of materials (mm)						Std. dev. of total	Average diameter (mm)		Duff depth	Fuel depth
		0-6	6-25	25-75	75+sound	75+rotten	Total		75+sound	75+rotten		
	Number	*Kilograms per hectare*							*Centimeters*			
Western hemlock/ blueberry and western hemlock/ skunk cabbage	33	2488	3945	2578	34 924	57 475	101 410	111 206	22.4	27.9	18.0	8.9
Mountain hemlock/ blueberry	35	2354	1659	1367	14 996	9639	30 015	55 726	21.1	21.8	11.4	4.3
Western hemlock-Alaska-cedar/ blueberry	3	291	1390	740	0	20 914	23 335	16 812	0	21.6	27.4	3.6
Western hemlock-redcedar/ blueberry	10	1076	1883	1592	101 410	50 122	156 083	299 546	31.0	29.2	6.4	18.5
Mixed conifer/ blueberry	37	381	1323	2331	10 356	23 627	38 018	66 979	16.8	29.2	43.2	3.0
Shore pine/ crowberry	11	134	493	964	1524	0	3115	5873	13.5	0	52.6	3.5
Sitka spruce/alder and Sitka spruce/ devilsclub	9	381	807	2869	1098	42 299	47 454	109 413	15.0	34.8	7.1	2.5

Table 4—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth by plant association or habitat types in English units

Habitat type	Sample size	Size class of materials (in)						Std. dev. of total	Average diameter (in)		Duff depth	Fuel depth
		0-1/4	1/4-1	1-3	3+sound	3+rotten	Total		3+sound	3+rotten		
	Number	*Tons per acre*							*Inches*			
Western hemlock/ blueberry and western hemlock/ skunk cabbage	33	1.1	1.8	1.2	15.6	25.6	45.2	49.6	8.8	11.0	7.1	3.2
Mountain hemlock/ blueberry	35	1.1	.7	.6	6.7	4.3	13.4	24.9	8.3	8.6	4.5	1.7
Western hemlock-Alaska-cedar/ blueberry	3	.1	.6	.3	0	9.3	10.4	7.5	0	8.5	10.8	1.4
Western hemlock-redcedar/ blueberry	10	.5	.8	.7	45.2	22.4	69.6	133.6	12.2	11.5	2.5	7.3
Mixed conifer/ blueberry	37	.2	.6	1.0	4.6	10.5	17.0	29.9	6.6	11.5	17.0	1.2
Shore pine/ crowberry	11	.1	.2	.4	.7	0	1.4	2.6	5.3	0	20.7	1.4
Sitka spruce/ alder and Sitka spruce/devilsclub	9	.2	.4	1.3	.5	18.9	21.2	48.8	5.9	13.7	2.8	1.0

Table 5—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth for cutover and old-growth stands of western hemlock and Sitka spruce in metric units

Stand status	Sample size	Size class of materials (mm)					Total	Std. dev. of total	Average diameter (mm)		Duff depth	Fuel depth
		0-6	6-25	25-75	75+sound	75+rotten			75+sound	75+rotten		
	Number	*Kilograms per hectare*							*Centimeters*			
Western hemlock-Sitka spurce all stands	78	1681	2309	3228	25 465	41 649	74 332	117 348	20.6	27.2	25.6	7.1
Western hemlock-Sitka spruce old growth	72	1636	2219	2892	21 654	34 095	62 496	87 871	20.6	25.6	26.2	6.4
Western hemlock-Sitka sprurce cutover	6	2130	3362	7308	71 238	132 277	216 315	275 001	20.8	37.3	18.3	16.8

Table 6—Average weight of downed woody materials by size class, diameter of large materials, duff depth, and fuel depth for cutover and old-growth stands of western hemlock and Sitka spruce in English units

Stand status	Sample size	Size class of materials (in)					Total	Std. dev. of total	Average diameter (in)		Duff depth	Fuel depth
		0-1/4	1/4-1	1-3	3+sound	3+rotten			3+sound	3+rotten		
	Number	*Tons per acre*							*Inches*			
Western hemlock-Sitka spruce all stands	78	0.7	1.0	1.4	11.4	18.6	33.2	52.3	8.1	10.7	10.1	2.8
Western hemlock-Sitka spruce old growth	72	.7	1.0	1.3	9.7	15.2	27.9	39.2	8.1	10.1	10.3	2.4
Western hemlock-Sitka spruce cutover	6	1.0	1.5	3.3	31.8	59.0	96.5	122.7	8.2	14.7	7.2	6.6

Graham and Cromack (1982) report 120 500 kilograms per hectare (53.8 tons per acre) of downed woody material in a closed-canopy Sitka spruce-western hemlock stand, and 107 000 kilograms per hectare (47.7 tons per acre) of downed wood in an open stand of the same type for stands located in the rain forests of the Olympic National Park. Again, these numbers are somewhat higher than those found for Alaska, 37 and 22 percent more than found in this present study.

One study in Alaska (Swanson and others 1984) examined coarse woody debris, but the study was limited to stream channels. A significant finding was that streams in cleared areas have three to six times the fuel loading found in streams in forested areas.

For the stands classified by plant associations, data from this study are in close agreement with those of Martin and others (1979); western hemlock/blueberry and western hemlock/blueberry/skunk cabbage stands averaged 101 410 kilograms per hectare (45.2 tons per acre) or about 96 percent of that reported in the Martin study.

Of the total 234 transects inventoried, only six were in old cutover stands. Four of these six transects were in mixed hemlock-spruce stands (fig. 2) and two were in pure Sitka spruce. An analysis of the 78 combined western hemlock and Sitka spruce type transects indicated a significant difference between cutover (fig. 3) and old-growth stands. The six cutover transects averaged 216 315 kilograms per hectare (96.5 tons per acre) as compared to the 72 old-growth transects yielding 87 871 kilograms per hectare (39.2 tons per acre) (tables 5 and 6). Thus, the cutover stands have an enormous quantity of down and dead woody materials—nearly 2.5 times the amount found on old-growth stands.

Old-growth stands of western hemlock and Sitka spruce without the cutover component averaged 62 496 kilograms per hectare (27.9 tons per acre) of down and dead woody materials, or only 59 percent of that reported by Martin and others (1979).

An excellent summary of coarse woody debris is presented by Harmon and others (1986). They also discuss the debris with respect to size, decay state, position (snags versus logs), and spatial arrangement. This study was limited to biomass with some information on size and soundness. Information is presented (tables 1 through 6) but is fairly sketchy due to the small sample size.

Management Implications

The literature implies that down and dead woody materials can be both a benefit and a detriment to the ecosystem (Harmon and others 1986). It is hazardous from a fire standpoint (Martin and others 1979, Maxwell and Ward 1981) but this likely is not a problem in the rain forests of southeast Alaska. Wallmo (1981) points out that downed wood in forest stands can be both a plus, in terms of cover, and a minus, in terms of hampering movement for wildlife. Others indicate that downed wood can affect outdoor recreation, range use, watershed, wildlife and fish resources, recreation and wilderness values (Martin and others 1979, Maxwell and Ward 1981). Although little is known about quantities of downed wood in Alaska, this material does not seem to be problem.

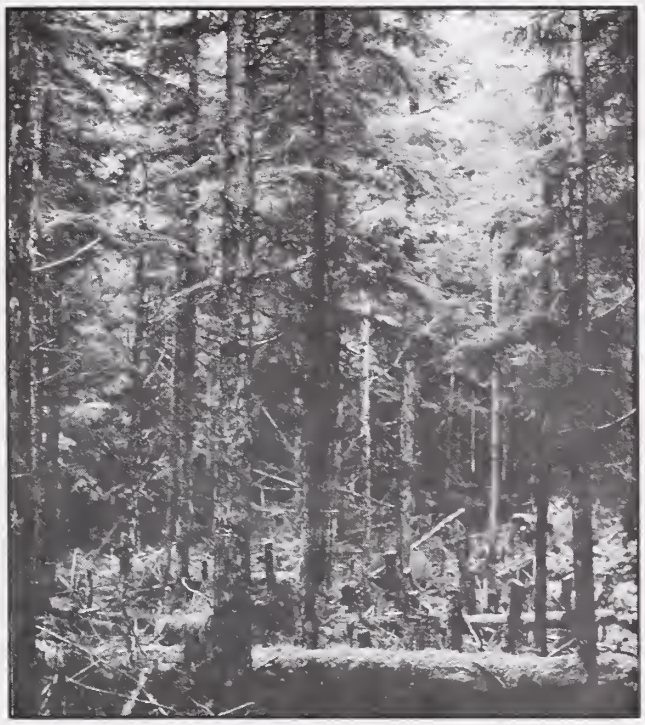

Figure 2 (right)—A cutover stand of mixed western hemlock and Sitka spruce.

Figure 3 (left)—Looking north from south boundary of horizontal-vertical vegetation profile plot in a cutover stand of mixed western hemlock and Sitka spruce.

Large quantities of downed woody material are left after logging, and some measures may be required to reduce this biomass so that it does not inhibit either wildlife movement or new seedlings from taking root and prospering. Only one of the types studied averaged more than two large pieces of downed wood (over 75 mm or 3 inches in diameter) per transect; the cutover western hemlock-Sitka spruce type averaged four large pieces per transect. Thus, downed woody materials in southeast Alaska forest stands do not seem to be a serious management problem.

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Data collected in conjunction with the multiresource inventory of southeast Alaska in 1985-86 included downed wood along 234 transects at 60 locations. Transects occurred in 11 forest types and 19 plant associations within the entire southeastern Alaska archipelago. Downed wood weights in forest types ranged from 1232 kilograms per hectare (0.6 ton per acre) in muskeg (shore pine) stands to 117 483 kilograms per hectare (52.4 tons per acre) in western redcedar stands. In plant association terminology, downed wood weights ranged from 3115 kilograms per hectare (1.4 tons per acre) in the shore pine/crowberry association to 156 083 kilograms per hectare (69.6 tons per acre) in western hemlock/blueberry associations.

Keywords: Forest biomass, downed woody fuels, coarse woody debris, Alaska.

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